

Evidence for Geographic Clustering of Reported Gonorrhea Cases: A Neighborhood-Level Analysis of Environmental Risk

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Abstract

The availability of alcohol, as measured by alcohol outlet density, is associated with numerous alcohol-related outcomes in a small area analysis. A number of studies suggest that high-risk sexual behavior should also be considered an alcohol-related outcome. This study assessed the geographic relationship between alcohol availability and high-risk sexual behavior at the neighborhood level. Ecological analysis tested the geographic relationship of off-sale, on-sale, and total alcohol outlet density with reported gonorrhea rates among 155 urban residential census tracts in New Orleans, Louisiana, during 1995. All alcohol outlet density variables were positively related to gonorrhea rates. Off-sale outlets per square mile was most strongly related to gonorrhea rates ($\beta=.582\pm.073$ [standard error]), accounting for 29% of the variance in gonorrhea rates. Interpreted as an elasticity, a 10% increase in off-sale alcohol outlet density accounts for a 5.8% increase in gonorrhea rates. Including the covariates of percent African American and percent unemployed in the model reduced, but did not remove, the effect of off-sale outlet density ($\beta=.192\pm.047$). These results indicate that there is a geographic relationship between alcohol outlet density and gonorrhea rates at the census tract level. Although these results cannot be interpreted causally, they do justify public health intervention as a next step in defining the relationship between alcohol availability and high-risk sexual behavior.

Keywords: STD, gonorrhea, alcohol

Introduction

A small literature exists that documents an association between alcohol consumption and high-risk sexual behavior. Among both heterosexuals and homosexuals, alcohol use is associated with a greater likelihood of unprotected sex, multiple sexual partners, and anal intercourse (1–5). Although the relationship between alcohol use and high-risk sexual behavior is complex, the pervasiveness of alcohol consumption in the United States would make even a small effect relevant from a public health perspective.

The availability of alcohol, as measured by alcohol outlet density, has been demonstrated to be geographically linked to numerous alcohol-related outcomes, including

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alcohol consumption (6), drunk driving arrests (7,8), fatal and injury traffic accidents (9), alcoholism rates (10–12), cirrhosis mortality (13), and assaultive violence (14,15). If high-risk sexual behavior is considered an alcohol-related outcome, the distribution of high-risk sexual behavior should also be geographically linked to alcohol outlet density.

High endemic rates of a sexually transmitted disease within a population are explained by a high reproductive rate of infection. The existence of a high reproductive rate of infection within a high-risk core population is determined by three factors, including a high rate of partner change (16). Rothenberg (17) and Potterat et al. (18) have demonstrated that gonorrhea is geographically concentrated in certain neighborhoods where a core group of high-risk individuals is found. Consequently, the existence of high endemic rates of a sexually transmitted disease within a particular geographic area may be explained in part by a higher rate of alcohol consumption among residents of the area.

The present study analyzed the geographic relationship between the density of alcohol outlets and a proxy for high-risk sexual behavior—reported gonorrhea rates—among 155 census tracts in New Orleans, Louisiana. The analysis tested the hypothesis that high-risk sexual behavior in New Orleans is geographically clustered in neighborhoods and that the clustering of high-risk behavior is predicted by the density of alcohol outlets.

Methods

In 1995 there were 1,834 licenses for alcohol outlets in New Orleans. These licenses are classified as either on-sale—alcohol is purchased for consumption on the premises—or off-sale—alcohol is purchased for consumption off the premises. On-sale outlets include bars and restaurants, while off-sale outlets include liquor stores and grocery or convenience stores. New Orleans, a city of approximately 420,521 residents, has one alcohol licensee for every 230 residents.

Rates of reported gonorrhea cases were used as a proxy for high-risk sexual behavior. The high prevalence of gonorrhea, as compared with syphilis or HIV, makes it a sensitive indicator of high-risk sexual behavior at the census tract level. While chlamydia also has a high prevalence, gonorrhea records are more complete because there is a longer history of reporting this disease. One problem associated with using gonorrhea case reports as a marker of high-risk sexual behavior is the possibility of differential reporting rates by public- and private-sector physicians. This limitation can be addressed by using the variable of mean employment status to estimate the proportion of the population served by public- or private-sector physicians within a census tract.

Alcohol outlet license data were obtained from the Louisiana Office of Alcoholic Beverage Control (ABC) for March of 1995. Only active licensees were included in the analysis. Data from the ABC included trade addresses for active alcohol licenses were georeferenced utilizing MapMarker (MapInfo Corporation, Troy, NY), which used 1995-updated TIGER files. A trade address was available for 99% of all listings (1,868 of 1,893). Georeferencing to street address (1,635) or to zip+4 centroids (186) achieved a georeferencing rate of 97%. Reported gonorrhea cases for 1995 were obtained from the Louisiana Office of Public Health (OPH), Office of Epidemiology. OPH reported a georeferencing rate of 95%.

Georeferenced alcohol outlets and reported gonorrhea cases were then linked to

their census tract by overlaying census tract boundary files. Density of outlets and rates of gonorrhea were obtained by dividing the total number of alcohol outlets and reported cases of gonorrhea within a census tract by census tract population estimates. Population estimates for 1994 were obtained from projections of US Census data made available by the Claritas Corporation (19). An additional density statistic, outlets per square mile, was calculated for alcohol outlets by dividing the number of outlets by the size of the census tract in square miles.

Sociodemographic data aggregated by census tract were also obtained from the Claritas Corporation (19). Sociodemographic data incorporated in the analysis included percent of population that was African American and percent of population over 16 years of age that was unemployed or not in the labor force.

To assure that all census tracts represented urban residential neighborhoods, certain census tracts were omitted from the 184 found in New Orleans. Rural census tracts (5) were removed by excluding those tracts with a population of less than 2,000 persons per square mile. Commercial or tourist census tracts (7) were removed by excluding those tracts with on-sale outlet densities of greater than 200 outlets per 1,000 persons. Industrial or nonresidential census tracts (17) were removed by excluding those tracts with a total population of less than 500. In all, 155 urban residential census tracts were included in the analysis.

Data Analysis

Least squares regression analysis was used to examine the relationship between gonorrhea rates and the covariates. Percent African American and percent adults unemployed were selected to control for the higher rates of reported gonorrhea among African Americans and the potential underreporting of gonorrhea by private-sector physicians, respectively. The complete model was composed of all these covariates.

All variables included in the analysis were transformed to their base-10 logarithm to adjust for skew and to permit analysis of the results as an elasticity. Observations with zero values were assigned a value equal to one-half of the value of the lowest observation before transformation. After transformation, the regression slope estimates the percent change in the dependent variable associated with a 1% increase in the independent variable.

Separate analyses were conducted for the two primary independent variables: outlet density, measured as outlets per person; and outlet density, measured as outlets per square mile. In each analysis, the three outlet density categories—off-sale outlet density, on-sale outlet density, and total outlet density—were added to the basic model.

Results

New Orleans census tracts in the study had a mean of 3,013 residents, 9.3 licensed alcohol outlets, and 17 reported cases of gonorrhea for the year. In addition, the census tracts had a mean of 61.4% African American residents and an unemployment rate of 14.9% (Table 1).

In the initial analysis, each outlet density variable was regressed with census tract gonorrhea rates. From this analysis we observed a strong relationship between reported gonorrhea rates and off-sale outlet density, measured either as outlets per square mile

Table 1 Means and Standard Deviations for Study Variables (n=155), New Orleans, LA, 1995

	Mean	SD
Sociodemographic Variables		
Percent African American	61.4%	32.6
Percent adults unemployed	14.9%	10.03
Population 1994	3,013	2,077
Outlet Density Variables		
Total number of outlets	9.28	7.12
Off-sale outlets per 1,000	1.75	1.55
On-sale outlets per 1,000	2.31	3.13
Total outlets per 1,000	4.05	4.07
Off-sale outlets per sq. mile	18.02	18.24
On-sale outlets per sq. mile	22.31	3119
Total outlets per sq. mile	40.17	42.58
Gonorrhea Variables		
1995 gonorrhea cases	17.1	15.3
1995 gonorrhea rate per 1,000	6.15	4.59

($\beta=.582\pm.073$) or outlets per person ($\beta=.374\pm.061$). The density of off-sale outlets per square mile accounted for 29% of the variance in gonorrhea rates, while the density of off-sale outlets per person accounted for 20% of the variance. On-sale outlet densities (i.e., outlets per person and outlets per square mile) demonstrated smaller but significant relationships with gonorrhea rates (Table 2). As with off-sale outlet density, the relationship was greater for on-sale outlet density measured as outlets per square mile ($\beta=.300\pm.069$) than as outlets per person ($\beta=.201\pm.061$).

The relationship between alcohol outlet density and reported gonorrhea rates can be interpreted as an elasticity because all covariates had been transformed to their base-10 logarithm. A 1% higher off-sale outlet density was associated with a 0.582% higher gonorrhea rate. Therefore, a 25% higher off-sale outlet density (one more off-sale outlet

Table 2 Coefficients with Standard Errors and Proportion of Variance of Explained (r^2) for Census Tract Gonorrhea Rates (n=155) Regressed on Different Independent Variables

	Coefficient (Standard Error)	r^2
Outlets per Square Mile		
Off-sale outlets	.582(.073)	.29
On-sale outlets	.300(.069)	.11
Total outlets	.476(.073)	.21
Outlets per Person		
Off-sale outlets	.374(.061)	.20
On-sale outlets	.201(.061)	.07
Total outlets	.488(.091)	.16

in a census tract, with a mean of four off-sale outlets) translates into a 14.5% higher gonorrhea rate, or 2.5 additional cases of gonorrhea.

The geographic association between gonorrhea cases and off-sale outlet density is illustrated in Figure 1. Areas where the outlet density is highest tend to be areas where the number of gonorrhea cases is the greatest.

To address the possibility that higher rates of gonorrhea among African Americans or underreporting of gonorrhea cases by private physicians could account for the relationships between outlet densities and gonorrhea rates, the covariates percent African

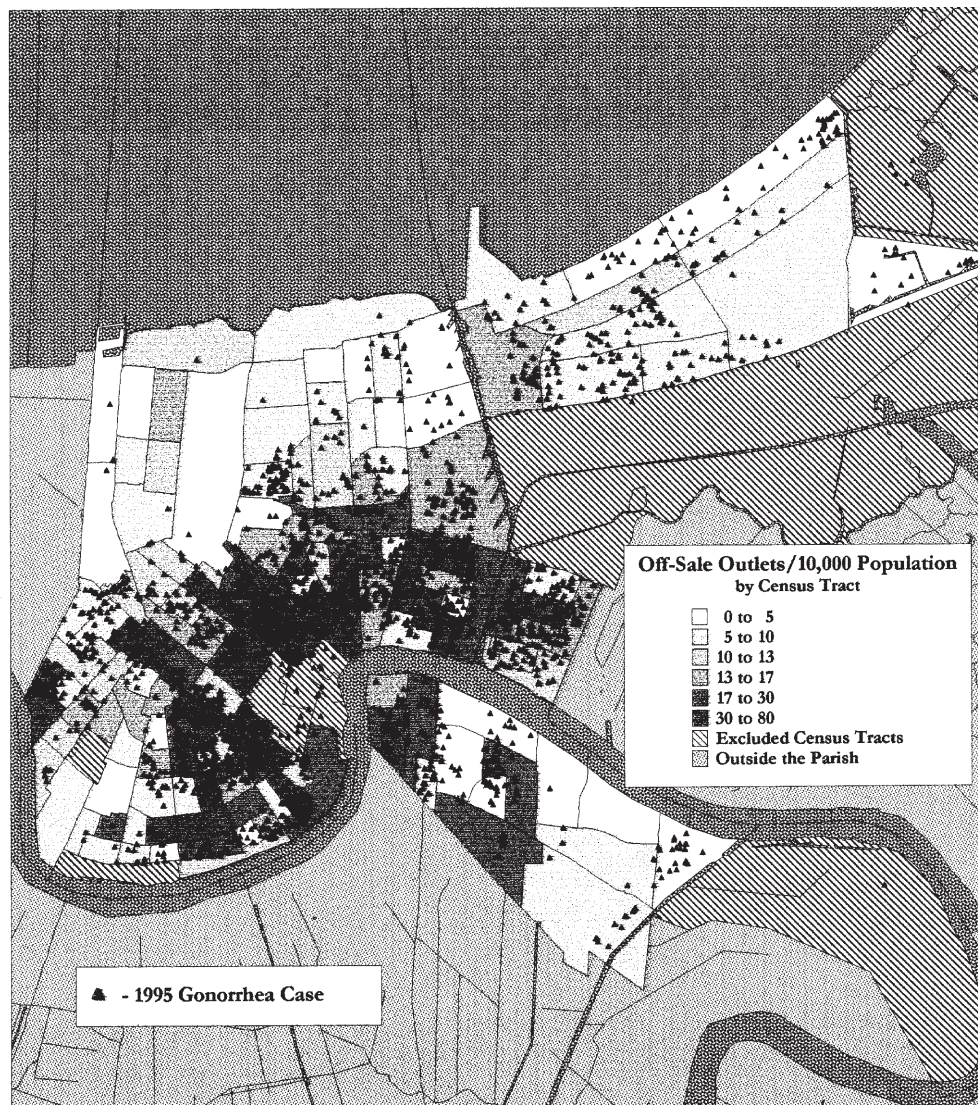


Figure 1 The 1995 census tract density of licensed off-sale alcohol outlets overlaid with reported cases of gonorrhea in New Orleans, LA, 1995.

American and percent unemployed were added to the model. Both percent African American ($\beta=.445\pm.051$) and percent unemployed ($\beta=.789\pm.106$) demonstrated strongly positive relationships with gonorrhea rates (Tables 3 and 4, Model 1). Adding these two covariates to the model increased the amount of variance explained to over 78%. The magnitude of the effect for each of the outlet density variables was reduced by the inclusion of these variables into the respective models. In every case, however, the effect of alcohol outlet density remained statistically significant. Outlet density measured as off-sale outlets per square mile demonstrated the strongest relationship, increasing the amount of additional variance explained by 3% ($\beta=.192\pm.047$) (Table 3, Model 2). The on-sale outlet density variables, on-sale outlet per square mile ($\beta=.108\pm.036$) and on-sale outlets per person ($\beta=.102\pm.030$), had the weakest relationships (Tables 3 and 4, Model 3). Interpreted as an elasticity, the relationship between off-sale outlet density and gonorrhea rates, controlling for covariates, indicates one additional off-sale outlet is associated with nearly one (.81) additional case of gonorrhea in the average New Orleans census tract during 1995.

Table 3 Coefficients (Standard Errors) for Regression Models in which the Dependent Variable is Census Tract Gonorrhea Rates and the Outlet Density Independent Variables Were Calculated as Outlets per Square Mile (n=155)

	Model 1	Model 2	Model 3	Model 4
Covariates				
Percent African American	.445(.051)*	.442(.048)*	.453(.049)*	.448(.048)*
Percent adults unemployed	.789(.106)*	.632(.107)*	.714(.106)*	.660(.105)*
Outlets per Square Mile				
Off-sale outlets		.192(.047)*		
On-sale outlets			.108(.036)*	
Total outlets				.171(.042)*
R ²	.76	.79	.77	.78

* p<0.001

Table 4 Coefficients (Standard Errors) for Regression Models in which the Dependent Variable is Census Tract Gonorrhea and the Outlet Density Independent Variables were Calculated as Outlets per Person (n=155)

	Model 1	Model 2	Model 3	Model 4
Covariates				
Percent African American	.445(.051)*	.441(.049)*	.451(.054)*	.452(.048)*
Percent unemployed	.789(.106)*	.691(.105)*	.738(.160)*	.680(.102)*
Outlets per 1,000 Residents				
Off-sale outlets		.123(.034)*		
On-sale outlets			.102 (.030)	
Total outlets				.221 (.047)
R ²	.76	.78	.78	.79

* p<0.001

Discussion

The analysis demonstrates that a strong geographic relationship exists between alcohol outlet density and reported gonorrhea rates at the census tract level, and that the relationship was partially independent of the effects of racial composition and level of unemployment across census tracts. These findings confirm the findings of Rothenberg, who showed that cases of reported gonorrhea cluster geographically when analyzed across urban residential neighborhoods (17). They also indicate that the grouping of cases is, in part, predicted by alcohol outlet density. The implications of these findings are significant, both in terms of using alcohol outlet density as a possible geographic indicator of an STD core group (20), and in terms of supporting theories that postulate a role for alcohol in promoting high-risk sexual behavior (21–23).

The fact that both outlets per person or outlets per square mile were associated with gonorrhea rates indicates that both these variables are reliable measures of the effect of alcohol outlet density. It should be noted that in studies of the effect of alcohol outlet density on other alcohol-related outcomes, limiting the analysis to a particular type of neighborhood (i.e., urban residential census tracts) is responsible for this consistency (15).

The covariates of percent African American and percent unemployed were also strongly associated with gonorrhea rates, independent of each other. The effect of the percent African American variable on gonorrhea rates is consistent with a higher risk of gonorrhea infection evidenced in African-American populations across the country. It may be that the same effects of concentrated disadvantage that are believed to be responsible for the higher rates of crime and mortality in African-American communities are also operating with regard to high-risk sexual behavior (24). On the other hand, the percent unemployed variable was introduced to control for the fact that gonorrhea cases are more likely to be reported by public-sector physicians as compared with private-sector physicians. The role employment plays in obtaining health insurance is undoubtedly a factor in determining whether an individual seeks treatment in the public or private sector. Unemployment, however, is also a marker for lack of access to treatment services. Lack of access to treatment services results in longer periods of infection, which increases the risk of transmission. It is impossible to differentiate between these two possible explanations for the effect of unemployment.

It should be noted that the data are cross-sectional and therefore do not permit a determination of directionality for the effects described. The analysis does not differentiate between competing explanations of the relationship between alcohol availability and high-risk sexual behavior in terms of cause and effect. In addition, the study represents a group-level analysis. Interpreting these findings in terms of an individual-level explanation could result in an ecologically fallacious inference.

With these limitations in mind, there are a number of hypotheses regarding the relationship between alcohol use and high-risk sexual behavior that are consistent with these findings (22,23). The census tract-level design permits multi-level explanations for the relationship involving both individual- and group-level mechanisms. Individual explanatory models view alcohol use both as a causal factor and as a confounder. Causal explanatory models at the individual level view alcohol outlet density as a direct indicator of increased individual access to alcohol that results in greater alcohol consumption. It has been shown that alcohol affects judgement and has a disinhibiting effect on

socially learned restraints (25,26). Alternatively, alcohol use may merely serve as a marker for a risk-taking personality (21,22). Risk takers may engage in a host of high-risk behaviors, including both alcohol use and high-risk sexual behavior. This analysis does not differentiate between these two possibilities because both risk takers and drinkers could be clustered in the high outlet density neighborhoods.

Group-level explanatory models view the “wetness” of the neighborhood as a social context that affects individual behavior (21). A wet neighborhood can be viewed as a geographic area where the norms of residents regarding alcohol consumption and alcohol-related behaviors are more likely to be conducive to high-risk sexual behavior. The high-risk norms in these areas evolve over time as residents come to expect the high-risk behaviors associated with drinking that they are more likely to observe in their daily social interactions (14). Such an effect for alcohol outlet density on neighborhood norms would affect all residents of the neighborhood to varying degrees, as opposed to an individual-level effect that only affects the drinker.

In any case, the geographic relationship between alcohol outlet density and gonorrhea cases has implications for future research. Neighborhood-level factors, such as alcohol outlet density, need to be considered as risk factors in the design and evaluation of preventive interventions. Population surveys should be designed to stratify by neighborhood to account for local risk factors like alcohol outlet density. In addition, multi-level studies of individuals within neighborhoods need to be conducted to distinguish between individual- and neighborhood-level risk factors. An individual-level effect for alcohol outlet density would reveal that individual access to alcohol is the primary factor accounting for the relationship; a neighborhood-level effect would reveal an effect for alcohol outlet density independent of individual access to alcohol outlets. Again, a neighborhood-level effect could mean that shared norms of sexual behavior for individuals living in high outlet density neighborhoods have been liberalized as a result of living in the neighborhood for a period of time.

Finally, these findings indicate the need for intervention studies. A preventive intervention designed to reduce alcohol outlet density is the logical next step. An intervention study would account for potential unmeasured confounders and help to determine the directionality of a potential causal association. Moreover, in a number of cities across the country, community groups are working toward the goal of reducing alcohol outlet density in problem neighborhoods. For example, some Chicago residents are organizing to take advantage of a city ordinance that permits precincts to vote out alcohol sales in the name of cleaning up the neighborhood (27). Preventive interventions could be organized around these efforts and evaluated in terms of their effect on STD rates.

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